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(54) **MEDIA-AGITATION TYPE PULVERIZER**

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B02C 17/18 (2006.01)

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CPC ***B02C 17/1815*** (2013.01); ***B02C 17/161*** (2013.01); ***B02C 17/168*** (2013.01); ***B02C 17/18*** (2013.01); ***B02C 17/184*** (2013.01); *B02C 17/16* (2013.01)

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USPC 241/171–172, 79, 79.2
See application file for complete search history.

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(57) **ABSTRACT**

A media-agitation pulverizer is capable of creating a uniformized, stable helicoidal flow in a mixture of pulverizing media and a raw material slurry, thereby performing pulverization/dispersion uniformly with satisfactory energy efficiency. The media-agitation pulverizer includes a guide ring installed to radially divide a lower region of a pulverization chamber into an inner section and an annular outer section, whereby a flow of a mixture of a raw material slurry and pulverizing media is formed as a helicoidal flow including a secondary flow flowing through a circulation flow path with respect to the guide ring; and rotational-flow suppressing device is provided within the pulverization chamber and adapted to strengthen the secondary flow of the helicoidal flow, thereby stabilizing the helicoidal flow.

17 Claims, 8 Drawing Sheets

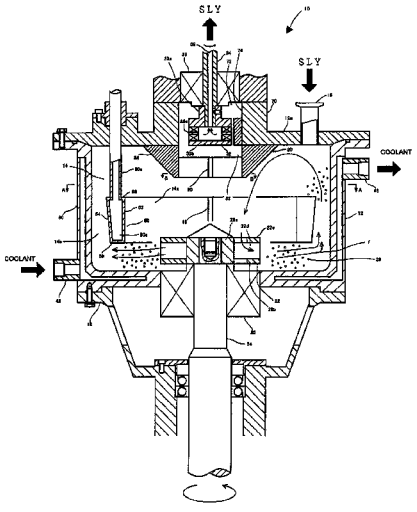

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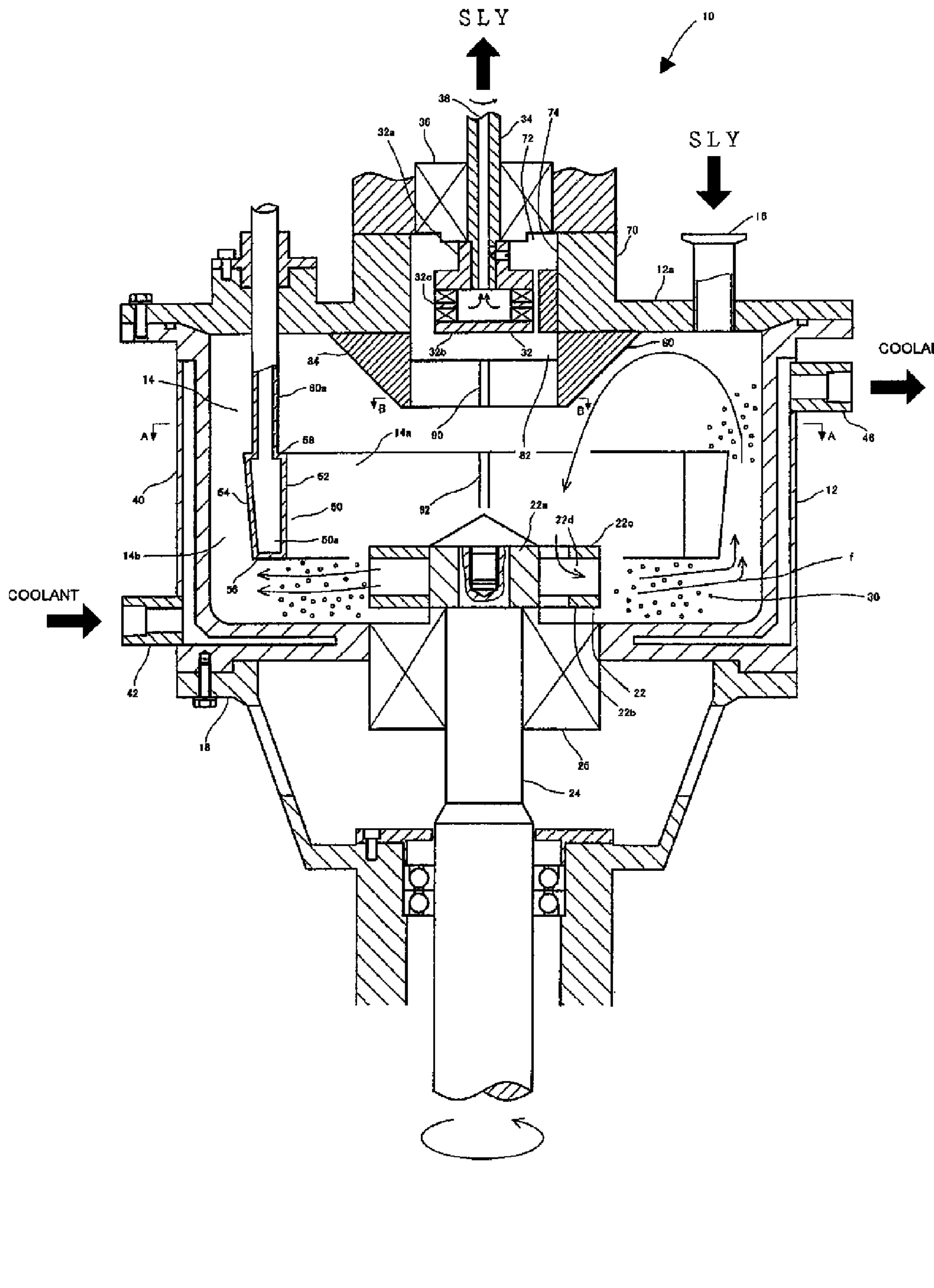
Fig.1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38
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32a
36
72
SLY
16
70
12a
32c
32b
32
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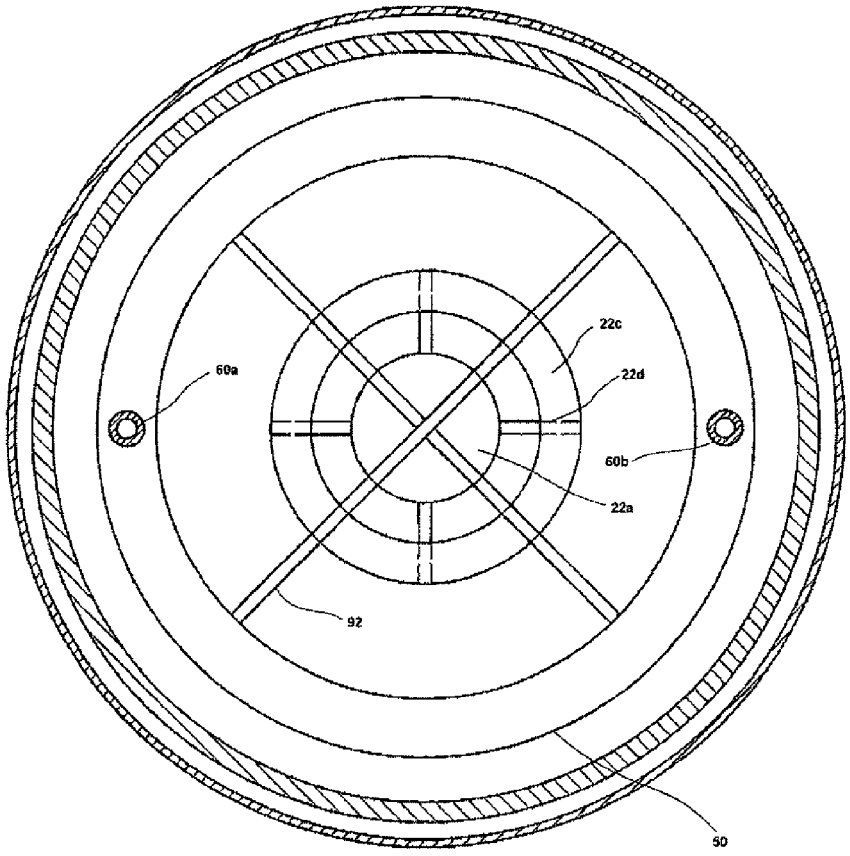
COOLANT
84
14
80a
B
90
B
A
14a
82
A
46
58
40
52
64
50
92
22a
22d
22c
12
14b
50a
f
56
30
COOLANT
42
22
22b
18
26
24

Fig.2



A－A

Fig.3

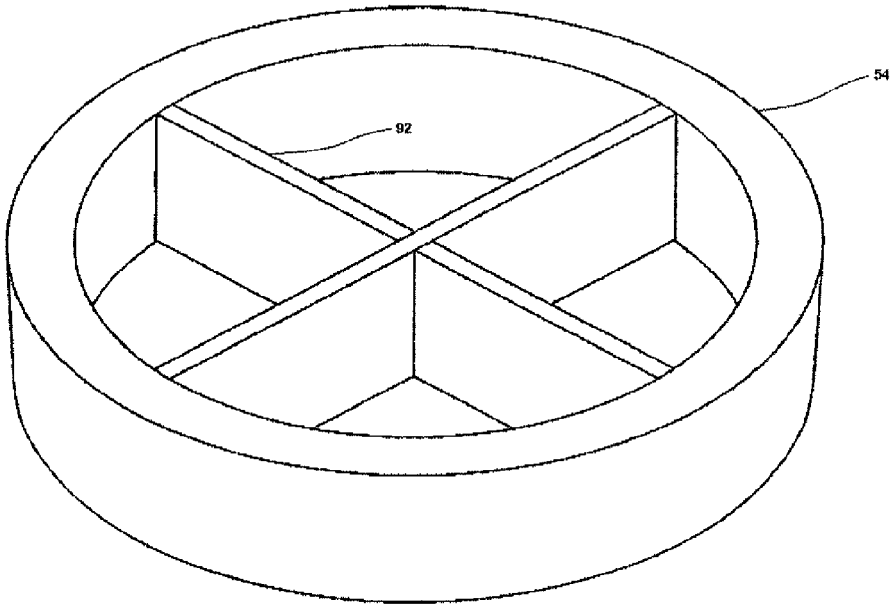


Fig.4

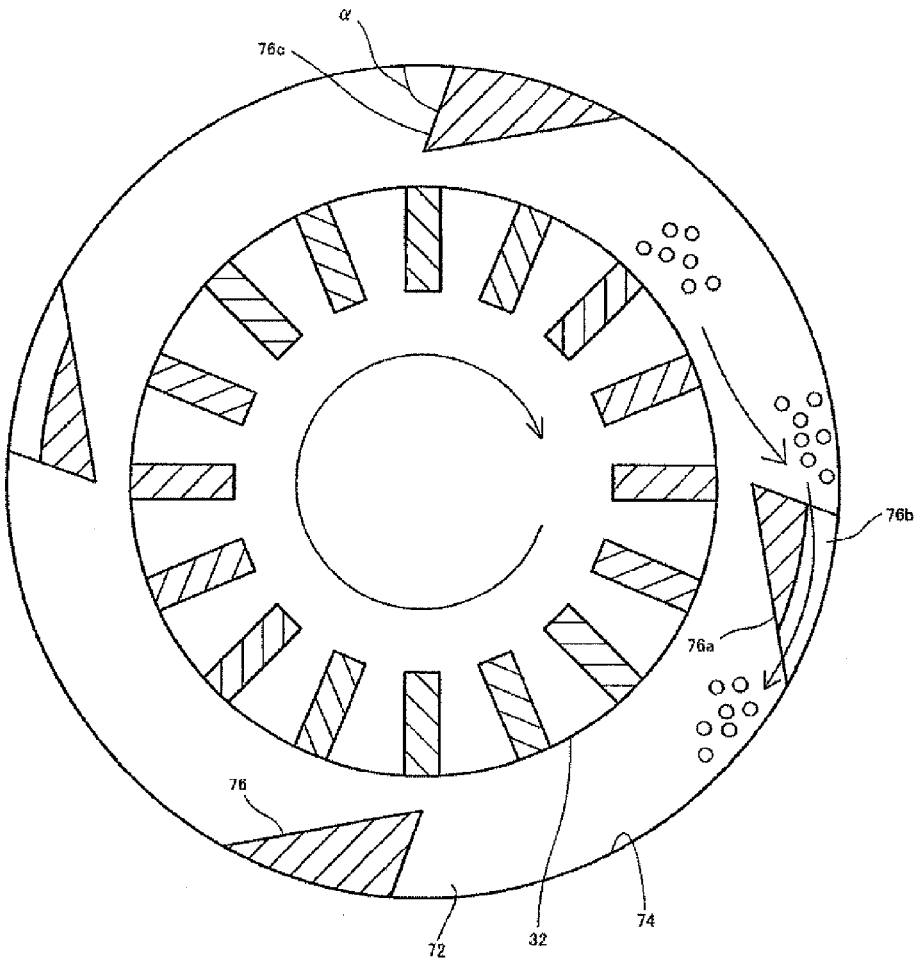
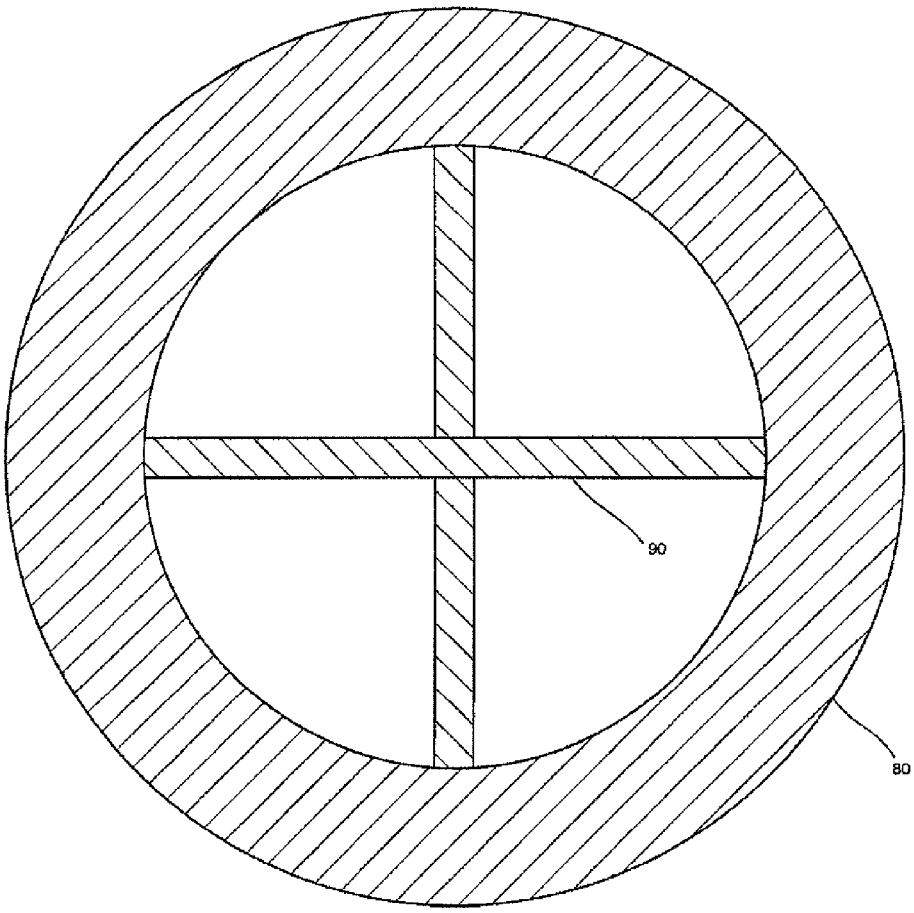


Fig.5



B—B

Fig.6

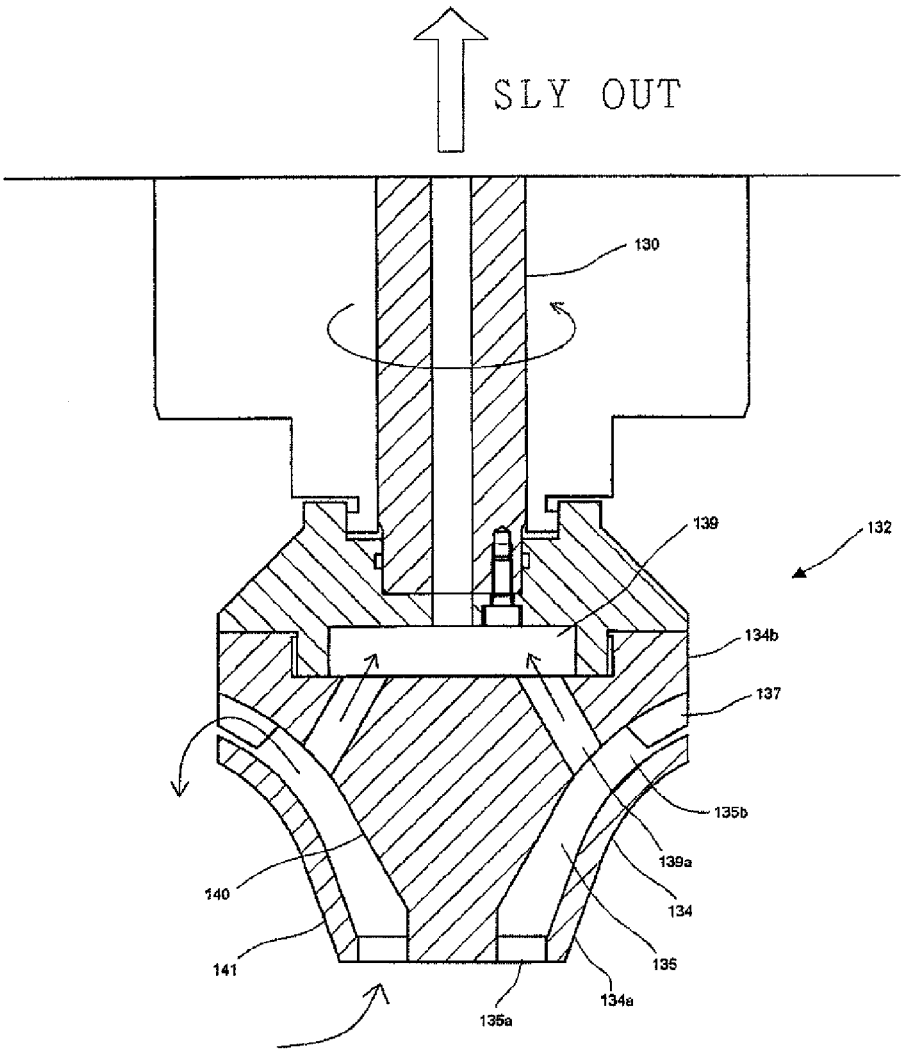

SLY OUT
130
139
132
134b
137
135b
139a
134
135
134a
135a
140
141

Fig.7

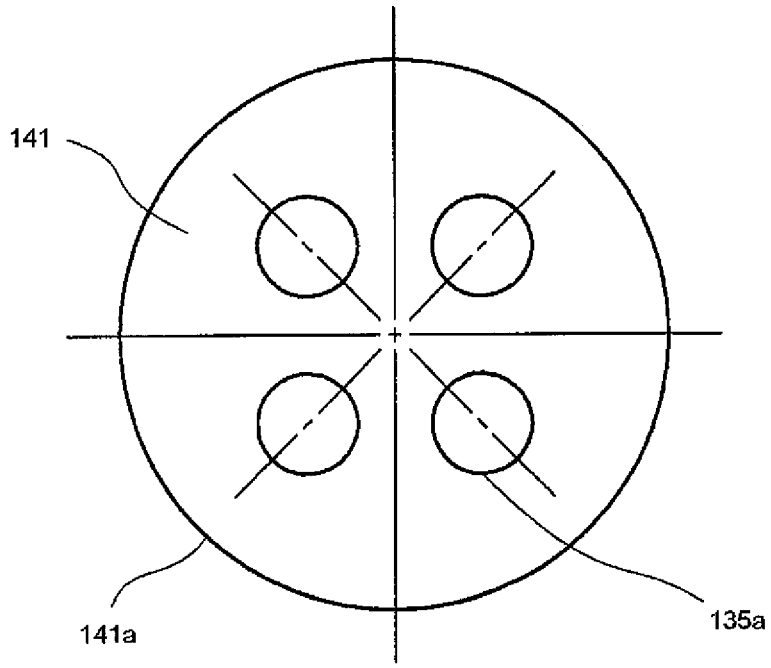


Fig.8

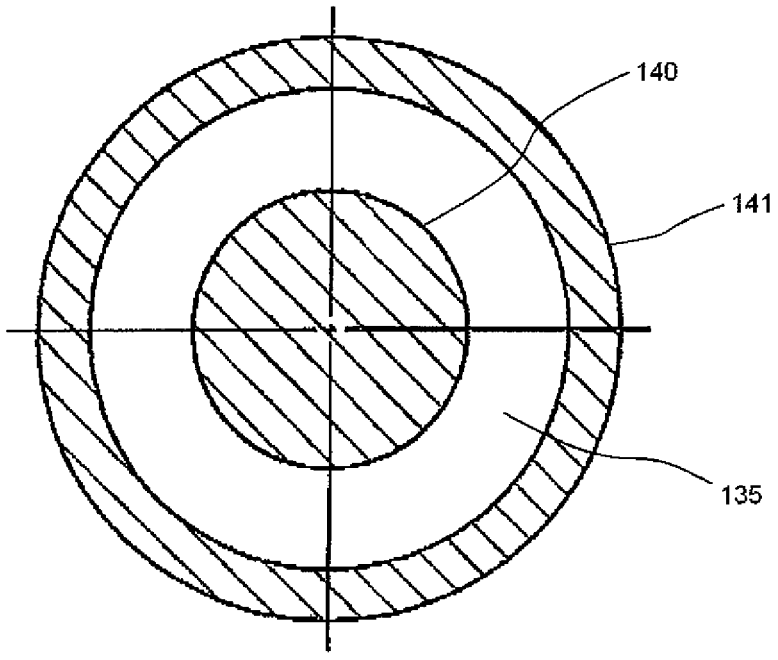
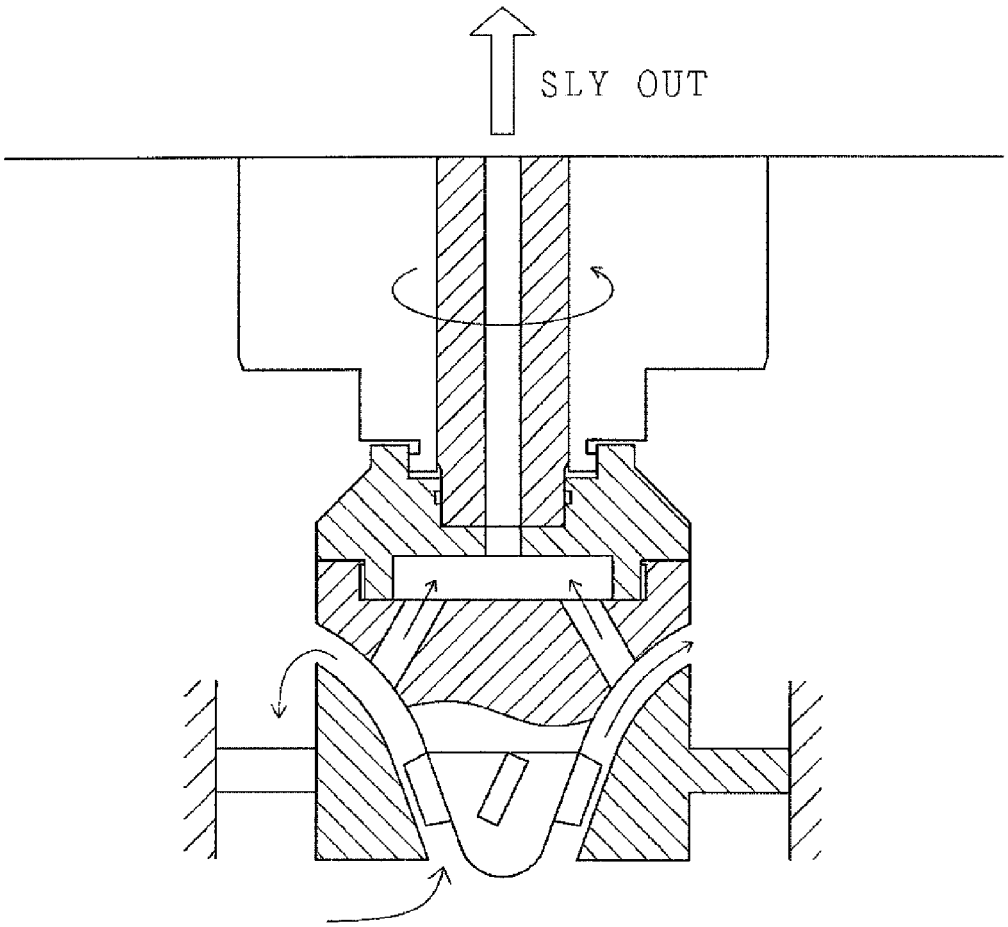


Fig.9



MEDIA-AGITATION TYPE PULVERIZER

TECHNICAL FIELD

The present invention relates to a media-agitation type pulverizer. The media-agitation type pulverizer of the present invention is particularly suitable for use in, but not limited to, mixing a raw material for ink, paint, pigment, ceramics, metal, inorganic material, dielectric material, ferrite, toner, glass, paper coating color or other nanoparticles, with pulverizing/dispersing media in the form of beads, to pulverize or disperse the raw material into fine particles.

BACKGROUND ART

As a media-agitation type pulverizer, there has been known a media-agitation (agitated media) mill proposed in JP 2005-199125 A.

The media-agitation mill proposed in the JP 2005-199125A comprises a pulverization tank including an end plate closing up an upper end thereof and internally having a pulverization chamber containing pulverizing media, a rotary shaft rotatably provided in the pulverization tank, and an agitating/separating member provided on a portion of the rotary shaft located inside the pulverization chamber and adapted to be rotatable integrally with the rotary shaft. This media-agitation mill is characterized in that an inner wall surface of the pulverization chamber and an outer peripheral surface of the agitating/separating member are formed in shapes conforming to each other, wherein the media-agitation mill further comprises a separation/discharge passage extending from the outer peripheral surface to penetrate through a central portion of the agitating/separating member and then extending from the central portion of the agitating/separating member to penetrate through a central portion of the rotary shaft and communicate with an outside of the pulverization chamber, and a pressure relief hole penetrating between upper and lower surfaces of the agitating/separating member in an axial direction of the rotary shaft to provide communication between upper and lower regions of an inside of the pulverization chamber.

However, in the media-agitation mill having the above structure, the pulverizing media are liable to be concentrated around a maximum-diameter portion where a centrifugal force is maximized, i.e., to be localized in a specific position, so that a dispersion or pulverization force varies with position, and the variation is large. Thus, there is a problem that a raw material is not uniformly dispersed or pulverized, causing difficulty in obtaining a high-quality product.

Therefore, the applicant of this application proposed a media-agitation type pulverizer capable of obtaining a high-quality product by a good pulverizing/dispersing action, in JP 2009-103529 (JP 2010-253339A).

The media-agitation type pulverizer proposed in the JP 2009-103529 comprises: a pulverization container having an upright cylindrical pulverization chamber containing pulverizing media in the form of beads; a raw-material-slurry supply port provided in the pulverization container; an agitating member disposed in a bottom region of the pulverization chamber and having a rotary shaft substantially coaxial with a central axis of the pulverization chamber; and a media separation member provided within the pulverization chamber and above the agitating member. This media-agitation type pulverizer is characterized in that it further comprises a guide ring installed to radially divide a lower region of the pulverization chamber into an inner section and an annular outer section, wherein an upward flow path of a mixture of the pulverizing media and the raw material slurry is created in the outer section of the lower region of the pulverization chamber.

In the media-agitation type pulverizer proposed in the JP 2009-103529, the guide ring is installed in the pulverization chamber, as mentioned above, whereby a flow of the mixture of the pulverizing media and the raw material slurry can be formed as a combined flow (i.e., helicoidal (spiral or helical) flow) consisting of a flow moving in a circumferential direction of the pulverization chamber (i.e., a primary flow) and a flow capable of regularly repeating a movement cycle of, after moving in a radially outward direction of the pulverization chamber toward an inner wall of the pulverization container, moving upwardly through the upward flow path between the guide ring and the pulverization container, and then moving downwardly from a central region of the pulverization chamber to return to the agitating member, via a space inward of the guide ring (i.e., a secondary flow). Thus, even if a volume ratio of beads to the pulverization chamber is relatively low, localization (uneven distribution) of the pulverization media can be suppressed to some extent to provide enhanced pulverization/dispersion efficiency.

However, the helicoidal flow formed by the media-agitation type pulverizer proposed in the JP 2009-103529 is unstable due to weakness and instability of the secondary flow thereof, so that centrifugal force distribution is likely to become uneven, which causes localization of the pulverization media in the helicoidal flow. Thus, there is a problem of non-uniform pulverization and not-so-satisfactory energy efficiency.

PRIOR ART DOCUMENTS

Patent Documents

Patent Document 1: JP 2005-199125A
Patent Document 2: JP 2010-253339A

DISCLOSURE OF THE INVENTION

Solution to the Technical Problem

It is therefore an object of the present invention to provide a media-agitation type pulverizer capable of creating a uniformized, stable helicoidal flow in a mixture of pulverizing media and a raw material slurry, without unevenness of a centrifugal force distribution, thereby performing pulverization/dispersion uniformly with satisfactory energy efficiency.

The above object is achieved by a media-agitation type pulverizer having the following features set forth in (1) to (17).

(1) A media-agitation type pulverizer comprising: a pulverization container including an end plate closing up an upper end thereof and having an upright cylindrical pulverization chamber containing pulverizing media in the form of beads; a raw-material-slurry supply port provided in the pulverization container; an agitating member disposed in a bottom region of the pulverization chamber and having a rotary shaft substantially coaxial with a central axis of the pulverization chamber; and a media separation member provided within the pulverization chamber and above the agitating member. The media-agitation type pulverizer is characterized in that it further comprises: a guide ring installed to radially divide a lower region of the pulverization chamber into an inner section and an annular outer section, whereby a flow of a mixture of the raw material slurry and the pulverizing media is formed as a helicoidal flow comprising a combination of a

primary flow flowing in a circumferential direction of the pulverization chamber and a secondary flow flowing through a circulation flow path which has an upward flow path and a downward flow path created, respectively, in the outer section and the inner section of the lower region of the pulverization chamber, with respect to the guide ring; and rotational-flow suppressing means provided within the pulverization chamber and adapted to suppress the primary flow while strengthening the secondary flow, thereby stabilizing the helicoidal flow.

(2) In the media-agitation type pulverizer set forth in (1), the rotational-flow suppressing means is formed by combining a plurality of plate members, and provided inside of the guide ring.

(3) In the media-agitation type pulverizer set forth in (1) or (2), the media separation member is disposed within a cylindrical-shaped media-separation-member receiving chamber provided in the end plate and having a bottom formed as a downwardly-facing opening opened to the pulverization chamber, wherein the media-separation-member receiving chamber has a diameter greater than a diameter of the media separation member and less than a diameter of the pulverization chamber.

(4) In the media-agitation type pulverizer set forth in (3), the media-separation-member receiving chamber has a radius greater than a radius of the media separation member by 10 to 30 mm.

(5) In the media-agitation type pulverizer set forth in any one of (1) to (4), the media separation member comprises: a circular top plate; a circular bottom plate disposed in axially spaced-apart relation to the top plate, and a plurality of blade members disposed between the top plate and the bottom plate at intervals in a circumferential direction thereof.

(6) In the media-agitation type pulverizer set forth in (5), the media separation member is formed in a multistage structure in which an intermediate plate is provided between the top plate and the bottom plate.

(7) In the media-agitation type pulverizer set forth in any one of (1) to (6), the guide ring has a structure which is internally formed with an annular space, and supported by a plurality of pipes attached to the pulverization container, in such a manner as to allow liquid to be supplied and discharged to/from the annular space through the pipes.

(8) In the media-agitation type pulverizer set forth in (7), each of the pipes is disposed to extend downwardly from above the pulverization container and support the guide ring by a lower end thereof.

(9) The media-agitation type pulverizer set forth in any one of (3) to (8) further comprises media-flow regulation means disposed to surround the downwardly-facing opening of the end plate and adapted to restrict the pulverizing media in the pulverization chamber from flowing into the media-separation-member receiving chamber.

(10) In the media-agitation type pulverizer set forth in (9), the media-flow regulation means is composed of a downwardly-tapered truncated conical-shaped guide member having an internal space, wherein the guide member is adapted to change an upward flow of the mixture of the raw material slurry and the pulverizing media created by an action of the agitating member, to a downward flow.

(11) The media-agitation type pulverizer set forth in any one of (3) to (10) further comprises at least one protrusion provided on an inner peripheral wall of media-separation-member receiving means, wherein the protrusion has a flow passage extending in a circumferential direction of the guide member to allow the pulverizing media to pass therethrough.

(12) In the media-agitation type pulverizer set forth in (11), the protrusion is formed in a triangular shape having a base on the inner peripheral wall of the media-separation-member receiving means.

(13) In the media-agitation type pulverizer set forth in (11) or (12), the flow passage is provided in a base portion of the triangular-shaped protrusion on the media-separation-member receiving means.

(14) In the media-agitation type pulverizer set forth in any one of (1) to (13), the media separation member comprises: an approximately conical-shaped or truncated conical-shaped member body having a reduced-diameter distal end portion and an enlarged-diameter base portion; a transfer passage for the mixture, provided in the member body of the media separation member to extend from at least one inlet adjacent to the reduced-diameter distal end portion to an annular outlet in the enlarged-diameter base portion along a peripheral wall thereof, wherein the inlet is adapted to act as a mixture suction hole for sucking the mixture to allow it to flow into the transfer passage; a plurality of blade members provided in the transfer passage at positions adjacent to the annular outlet and arranged side-by-side along the annular outlet to perform a pulverizing-media pumping action; and a raw-material-slurry outlet passage branched from the transfer passage at a position upstream of the blade members.

(15) In the media-agitation type pulverizer set forth in any one of (1) to (13), the media separation member comprises: an approximately conical-shaped or truncated conical-shaped central member; and a generally hollow truncated conical-shaped outer member having an inner periphery located in spaced-apart relation to an outer periphery of the central member, wherein the transfer passage is formed by the space between the outer periphery of the central member and the inner periphery of the outer member.

(16) In the media-agitation type pulverizer set forth in (15), the outer member of the media separation member has a distal end fixed to a distal end of the central member of the media separation member.

(17) In the media-agitation type pulverizer set forth in (16), the distal end of the outer member of the media separation member is formed as a circular distal end plate, wherein the mixture suction hole is formed in the circular distal end plate.

Effect of the Invention

As described above, the media-agitation type pulverizer of the present invention is capable of controlling the helicoidal flow of the mixture of the pulverizing media and the raw material slurry to suppress a rotational flow in the circumferential direction of the pulverization chamber (i.e., primary flow) while strengthening the secondary flow (i.e., a circulation flow around the guide ring), thereby stabilizing the helicoidal flow. Thus, it becomes possible to facilitate uniformizing distribution of the pulverizing media in the flow to provide a flow having highly repetitive shear optimal to pulverization/dispersion with satisfactory energy efficiency.

In some cases, a satisfactory helicoidal flow is formed without employing the rotational-flow suppressing means as in the present invention. However, this is an accidental result in a situation where all conditions such as viscosity of the mixture are met, but a perfect helicoidal flow as in the present invention is not always formed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view illustrating a media-agitation type pulverizer according to one embodiment of the present invention.

FIG. **2** is a sectional view taken along the line A-A in FIG. **1**.

FIG. **3** is a perspective view schematically illustrating rotational-flow suppressing means.

FIG. **4** is a horizontal sectional view illustrating an internal structure of a media-separation-member receiving chamber.

FIG. **5** is a sectional view taken along the line B-B in FIG. **1**.

FIG. **6** is an enlarged sectional view illustrating an example of a modification of a centrifugal media separation member.

FIG. **7** is a bottom view of the centrifugal media separation member illustrated in FIG. **6**.

FIG. **8** is a horizontal sectional view of the centrifugal media separation member illustrated in FIG. **6**, taken in the vicinity of a distal end thereof.

FIG. **9** is an enlarged sectional view illustrating another example of the modification of the centrifugal media separation member.

DESCRIPTION OF EMBODIMENTS

With reference to the accompanying drawings, the present invention will now be described in connection with a media-agitation type pulverizer according to one embodiment thereof.

FIG. **1** illustrates a media-agitation type pulverizer **10** according to one embodiment of the present invention. This media-agitation type pulverizer **10** comprises an upright cylindrical pulverization container **12** including an end plate **12***a* closing up an upper end thereof. The pulverization container **12** internally has a columnar pulverization chamber **14**, and which is equipped therein with a raw-material-slurry supply port **16** for introducing a raw material in a slurry form (raw material slurry) into the pulverization chamber **14**.

An agitating member **22** is rotatably disposed in the center of a bottom region of the pulverization chamber **14** of the pulverization container **12**. The agitating member **22** is composed of an impeller which comprises, for example, a pair of annular plates **22***b*, **22***c* fixed to an outer periphery of a boss **22***a* in vertically spaced-apart relation to each other, and a plurality of blades **22***d* disposed between the plates **22***b* and **22***c*.

A rotary drive shaft **24** serving as an agitating-member driving shaft is fixed to the agitating member **22**. The rotary drive shaft **24** has an upper end attached to the hub **22***a* of the agitating member **22** and extends axially downwardly to penetrate through the pulverization container **12** and a frame **18**. A lower end of the rotary drive shaft **24** is connected to a driving source via a non-illustrated conventional driving mechanism to allow the rotary drive shaft **24** to be rotationally driven in the direction indicated by the arrow in FIG. **1**. Preferably, the rotary drive shaft **24** has a rotation axis aligned with a central axis of the pulverization chamber **14**. Further, the rotary drive shaft **24** is provided with a shaft seal **25** (e.g., a mechanical seal).

In place of the above centrifugal impeller, the agitating member **22** may be composed of an oblique-flow impeller.

As is well known in the field of media-agitation type pulverizers, pulverizing media **30** in the form of beads (which are illustrated in FIG. **1** in a significantly enlarged manner) are contained in the pulverization container **12**. As the pulverizing media **30**, it is possible to use a type having a diameter of 0.02 to 2 mm. A total volume of the pulverizing media **30** is in the range of 30% to 75% of a volume of the pulverization chamber **14**. In a typical media-agitation type pulverizer, the total volume of the pulverizing media is in the range of 75% to 90% of the volume of the pulverization chamber. Thus, the media-agitation type pulverizer of the present invention is capable of performing soft pulverization/dispersion with less constraining force.

A centrifugal media separation member **32** is disposed in a top region of the pulverization chamber **14** of the pulverization container **12** and adjacent to the central portion of the pulverization chamber **14**, in opposed and axially spaced-apart relation to the agitating member **22**, and adapted to separate the pulverizing media **30** dispersed in the raw material slurry from the raw material. The media separation member **32** comprises: a boss **32***a* having a tubular boss body formed with an internal space in a lower portion thereof; and a closing plate **32***b* for closing up the lower portion of the boss body. The boss body of the boss **32***a* is provided with a plurality of openings, and the media separation member **32** is adapted to introduce only the raw material slurry into the internal space of the boss body through the openings. While it is preferable that the media separation member **32** is disposed in coaxial relation with the agitating member **22**, the axes thereof may be offset from each other. A hollow rotary drive shaft **34** is fixed to that media separation member **32**. The rotary drive shaft **34** extends upwardly to penetrate through the end plate **12***a*, and an upper end of the rotary drive shaft **34** is connected to a driving source via a non-illustrated conventional driving mechanism to allow the rotary drive shaft **34** to be rotationally driven in the direction indicated by the arrow in FIG. **1**. Further, the rotary drive shaft **34** is provided with a shaft seal **36** (e.g., a mechanical seal). The hollow space of the rotary drive shaft **34** is communicated with the internal space of the media separation member **32** to form a raw-material-slurry exit **38**. As the media separation member, a conventional screen may be used.

The centrifugal media separation member may have a configuration comprising: a circular top plate; a circular bottom plate disposed in axially spaced-apart relation to the top plate, and a plurality of blade members disposed between the top plate and the bottom plate at intervals in a circumferential direction thereof. Further, the media separation member may have also a multi-stage configuration wherein a circular intermediate plate **32***c* is provided between the top plate and the bottom plate.

A jacket **40** is provided around an outer periphery of the pulverization container **12** to allow a cooling or heating medium (typically, a cooling medium such as a coolant water) to flow therethrough so as to adjust an internal temperature of the pulverization chamber **14**. This jacket **40** has a coolant water inlet **42** provided in a lower portion thereof to introduce a coolant water therethrough and a coolant water outlet **46** provided in an upper portion thereof to discharge the coolant water therefrom.

The end plate **12***a* is adapted to be detached to open the pulverization container **12**, so that the pulverization container **12** can be readily subjected to maintenance.

In the media-agitation type pulverizer of the present invention, the agitating member **22** may be driven at a rotational circumferential speed ranging from 5 to 30 m/s, and the media separation member **32** may be driven at a rotational circumferential speed ranging from 10 to 20 m/s.

A guide ring **50** is disposed in a lower region of the pulverization chamber **14**. This guide ring **50** comprises: an annular inner-peripheral plate **52**; an annular outer-peripheral plate **54** disposed in spaced-apart relation to the inner-peripheral plate **52** in a radially outward direction; an annular lower plate **56** forming a bottom wall; and an annular upper plate **58** forming a top wall, and internally has a liquid-tight space.

The guide ring **50** is installed to radially divide the lower region of the pulverization chamber **14** into an inner section

14*a* and an annular outer section 14*b*. The inner section 14*a* of the lower region of the pulverization chamber **14** serves as an upward flow path for a mixture of the pulverizing media and the raw material slurry, and the outer section 14*b* of the lower region of the pulverization chamber **14** serves as an upward flow path for the mixture of the pulverizing media and the raw material slurry. Thus, in the pulverization chamber **14**, a flow of the mixture of the pulverizing media and the raw material slurry is formed as a combined flow (i.e., helicoidal flow) consisting of a flow moving in a circumferential direction of the pulverization chamber (i.e., a primary flow) and a flow capable of regularly repeating a movement cycle of, after moving in the radially outward direction of the pulverization chamber toward an inner wall of the pulverization container, moving upwardly through the upward flow path between the guide ring and the pulverization container, and then moving downwardly from a central region of the pulverization chamber to return to the agitating member, via a space inward of the guide ring (i.e., a secondary flow). As mentioned above, this helicoidal flow has suffered from the problem of instability due to weakness of the secondary flow thereof.

Further, a rotational-flow suppressing means **92** (see FIGS. **2** and **3**) is provided in the inward space of the guide ring **50** to control the helicoidal flow of the mixture of the pulverizing media and the raw material slurry flowing axially downwardly through the inward space within the pulverization chamber **14**, to suppress a rotational flow while strengthening the secondary flow. Preferably, the rotational-flow suppressing means **92** is formed in a cruciform shape by combining a plurality of plate members. The combined flow of the circumferential flow (primary flow) and the axial flow (secondary flow) created, mainly, by actions of the agitating member **22** and the guide ring **50**, is controlled to strengthen the secondary flow by the newly provided rotational-flow suppressing means **92**, thereby providing a stable helicoidal flow. This makes it possible to uniformize distribution of the pulverizing media contained in the combined flow and eliminate unevenness of a centrifugal force distribution to produce vigorous shearing forces between the pulverizing media, thereby further enhancing the function of the pulverizing media. A portion of the agitating member **22** located beneath the rotational-flow suppressing means **92** appears in FIG. **2**. However, this is only for convenience of illustration, and the portion does not actually appear.

The guide ring **50** has a structure which is internally formed with an annular space **50***a*, as mentioned above, and supported by a plurality of pipes **60***a*, **60***b* (see FIG. **2**) attached to the pulverization container, in such a manner as to allow a coolant water to be supplied and discharged to/from the annular space through the pipes **60***a*, **60***b*. Therefore, in the present invention, the raw material slurry can also be cooled from inside the pulverization container **12**.

Preferably, each of the pipes **60***a*, **60***b* is disposed to extend downwardly from above the pulverization container **12** and support the guide ring **50** by a lower end thereof, as illustrated in FIG. **1**.

Preferably, the guide ring **50** has a lower end located at a position equal to or higher than an upper end of the agitating member **22**, and an upper end located at a position downwardly spaced apart from a lower end of the media separation member **32** by a predetermined distance, as illustrated in FIG. **1**.

Preferably, a distance between an outer peripheral wall of the guide ring **50** and an inner peripheral wall of the pulverization container **12** is in the range of 10 to 50 mm. If the distance is less than the lower limit, movement of the beads will be excessively constrained. On the other hand, if the distance is greater than the upper limit, the freedom of the movement will be excessively increased.

Preferably, the guide ring **50** has a height which is ⅓ to ⅔ a height of the pulverization chamber. If the height is less than the lower limit, control of a bead flow will become insufficient. On the other hand, if the height is greater than the upper limit, smoothness of the bead flow will be impaired.

As illustrated in FIG. **1**, a central portion of the end plate **12***a* is formed as a thick-walled portion **70** increased in thickness as compared with a surrounding portion (having a thickness greater than a height of the media separation member), and provided with a through-hole **72**. The media separation member **32** is rotatably received in the through-hole **72**, as illustrated in FIG. **1**. In other words, the through-hole **72** serves as a media-separation-member receiving chamber or a media separation chamber, which receives therein the media separation member **32**, and the thick-walled portion **70** serves as media-separation-member receiving means. In order to form the media-separation-member receiving chamber, the entirety of the end plate **12***a* may be formed to have a thickness equal to that of thick-walled portion **70**. However, this is not a realistic way, because it leads to an increase in material cost and weight of the pulverizer.

Media-flow regulation means **80** is provided on a central region of a lower surface of the end plate **12***a* to restrict the pulverizing/dispersing media **30** in the pulverization chamber **14** from flowing into the media-separation-member receiving chamber. The media-flow regulation means **80** is composed of a downwardly-tapered truncated conical-shaped guide member which has a cylindrical space **82** penetrating therethrough in continuous relation to the through-hole **72**, and an outer peripheral surface serving as a guide surface **84**. This media-flow regulation means **80** also has a function of changing an upward flow of the mixture of the raw material slurry and the bead-form pulverizing media created by an action of the agitating member **22**, to a downward flow along the guide surface **84**, thereby eliminating factors causing instability in the mixture flow. Further, based on the controlled flow of the mixture of the raw material slurry and the pulverizing media, media freely flowing within the pulverization chamber **14** can be regulated as much as possible, so that it becomes possible to reduce a concentration of media around the media separation member **32**, and restrict media from flying toward the media separation member **32**, thereby enhancing a separation capacity of the media separation member.

Preferably, a rotational-flow suppressing means **90** (see FIG. **1**) is provided in an internal space of the media-flow regulation means **80** to prevent turbulence in the mixture flow flowing from the pulverization chamber into the media-separation-member receiving chamber via the internal space. Preferably, the rotational-flow suppressing means **90** is formed in a cruciform shape by combining a plurality of plate members. Based on providing the rotational-flow suppressing means **90**, it becomes possible to strengthen the secondary flow of the helicoidal flow of the mixture within the media-separation-member receiving chamber, thereby stabilizing the helicoidal flow to further enhance the function of the media separation member.

The media-separation-member receiving means (thick-walled portion **70**) has an inner peripheral surface **74** provided with at least one, preferably a plurality of flow control protrusions **76** (see FIG. **5**).

As illustrated in FIG. **5**, the flow control protrusion **76** is formed in an approximately triangular shape having a base on the inner peripheral surface **74**, in horizontal cross-section, and a media flow passage **76***b* is formed in a base portion (a portion adjacent to the base) **76***a* of the flow control protru-

sion **76**. Preferably, an angle α defined between the inner peripheral surface **74** and one side **76***c* of the triangular flow control protrusion **76** having an inflow port of the media **30** i.e., opposed to the media flow, is set to an acute angle.

When the angle α is set to an acute angle, the opposed side **76***c* functions to direct the media toward the inner peripheral surface **74** of the media-separation-member receiving means (thick-walled portion **70**), i.e., in a direction away from the media separation member **32**, which is preferable in view of reducing a concentration of the media around the media separation member **32** to enhance a media separation function of the media separation member **32**.

In the case where the angle α is set to an acute angle, the media are likely to stagnate in an acute-angled region. In this embodiment, the media flow passage **76***b* circumferentially penetrating through the base portion of the triangular flow control protrusion **76** is provided to allow the media to flow toward a downstream side via the media flow passage **76***b*, thereby preventing the media from stagnating in the acute-angled region.

A formation position of the media flow passage **76***b* may be changed depending on a height position of the flow control protrusion **76**.

In the above embodiment, the thick-walled portion **70** is provided in the end plate **12**, and the media-separation-member receiving chamber is provided in the thick-walled portion **70**. Alternatively, an inside of the media-flow regulation means **80** may be formed as the media-separation-member receiving chamber.

In other words, the media-agitation type pulverizer may comprise media-separation-member receiving means provided with a media-separation-member receiving chamber receiving therein the media separation member and disposed on the lower surface of the end plate, wherein an outer peripheral surface of the media-separation-member receiving means is formed as media-flow regulation means adapted to restrict the pulverizing/dispersing media in the pulverization chamber from flowing into the media-separation-member receiving chamber.

In this case, the media-separation-member receiving means is composed of a downwardly-tapered truncated conical-shaped member having the cylindrical internal space, and disposed in a central region of the lower surface of the end plate, wherein an outer peripheral surface of the truncated conical-shaped member is formed to serve as a guide member adapted to change an upward flow of the mixture of the raw material slurry and the bead-form pulverizing/dispersing media created by the action of the agitating member, to a downward flow.

In this modification, at least one protrusion is provided on an inner peripheral wall of the above media-separation-member receiving means, and a flow passage is provided in the protrusion to extend in a circumferential direction of the guide member to allow the bead-form pulverizing/dispersing media to pass therethrough so as to create an outward flow of the media, as with the above embodiment.

During operation of the above media-agitation type pulverizer, the agitating member **22** is rotationally driven, while introducing the raw material slurry containing target particles as a raw material to be pulverized, into the pulverization chamber **14** through the raw-material-slurry supply port **16**. The slurry introduced into the pulverization chamber **14** is moved downwardly toward the agitating member **22**, with a rotational flow of the mixture of the slurry and the media **30** which has already been formed in the pulverization chamber **14**, and then agitated and mixed with the mixture by the agitating member **22**. In this process, the flow of the mixture of the raw material slurry and the pulverizing/dispersing media is controlled to strengthen the secondary flow by the rotational-flow suppressing means **92**, and thereby formed as a stable helicoidal flow. Subsequently, the slurry and the media **30** are moved radially outwardly to the inner wall of the pulverization container **12**. Then, the mixture of the slurry and the media **30** subjected to agitation and mixing is formed as a flow f moving upward through the upward flow path between the inner wall of the pulverization chamber **14** and the guide ring **50**. When the flow moves fully upwardly, it is changed to the aforementioned downward flow.

Concurrently, in the media-separation-member receiving chamber, a rotational movement is given to the raw material slurry and the media by the media separation member **32**. According to the rotational movement, the media having a relatively large mass are urged radially outwardly and separated from the slurry. In this process, a part of the target particles still having a relatively large particle size due to insufficient pulverization exhibit the same behavior as that of the media. On the other hand, the slurry containing particles sufficiently pulverized and reduced in mass are introduced into the internal space of the media separation member **32**, and discharged to the outside of the media-agitation type pulverizer via the raw-material exit **38** inside the rotary drive shaft **34**. Based on the above configuration, in the regulated flow, target particles as a raw material are subjected to good pulverization and dispersion by means of contact with the freely-moving pulverizing media, so that a high-quality product is obtained. In addition, based on the above functions, the media-agitation type pulverizer of the present invention can achieve pulverization providing a sufficiently narrow particle size distribution width. Furthermore, the media-agitation type pulverizer of the present invention requires a less amount of pulverizing media.

In the media-agitation type pulverizer of the present invention, the agitating member **22** is sufficiently spaced apart from the media separation member **32**, so that a risk of interference with the media separation member **32** is extremely low.

The media-agitation type pulverizer of the present invention may employ a centrifugal media separation member **132** as illustrated in FIGS. **6**, **7** and **8**. This centrifugal media separation member **132** comprises an approximately conical-shaped or truncated conical-shaped member body **134** having a reduced-diameter distal end portion **134***a* and an enlarged-diameter base portion **134***b*. A lower end of a drive shaft **130** is fixed to a center of the enlarged-diameter base portion **134***b* to allow the media separation member **132** to be rotated according to rotation of the drive shaft **130**. A transfer passage **135** for the mixture is provided in the member body **134** to extend from at least one inlet **135***a* adjacent to the reduced-diameter distal end portion **134***a* to an annular outlet **135***b* in the enlarged-diameter base portion **134***b* along a peripheral wall thereof. The inlet **135***a* is adapted to act as a mixture suction hole for sucking the mixture to allow it to flow into the transfer passage **135**. A plurality of blade members **137** are provided in the transfer passage **135** at positions adjacent to the annular outlet **135***b* and arranged side-by-side along the annular outlet to perform a media pumping action. Further, a raw-material-slurry outlet passage **139** is branched from the transfer passage **135** at a position upstream of the blade members **137**.

The enlarged-diameter base portion **134***b* of the member body **134** is internally formed with a treated-raw-material-slurry collecting space **139** which is an approximately disk-shaped space, and the raw-material-slurry outlet passage **139***a* and a raw-material-slurry exit **131** are communicated with the treated-raw-material-slurry collecting space **139**.

The member body **134** of the media separation member comprises an approximately conical-shaped or truncated conical-shaped central member **140**, and a generally hollow truncated conical-shaped outer member **141** (see FIG. **8**) having an inner periphery located in spaced-apart relation to an outer periphery of the central member **140**. The transfer passage **135** is formed by the space between the outer periphery of the central member and the inner periphery of the outer member.

Preferably, the member body **134** is configured such that the outer member **141** has a distal end fixed to a distal end of the central member **140**.

Specifically, the distal end of the outer member **141** is formed as a circular distal end plate **141***a* as illustrated in FIGS. **6** and **7**, and the mixture suction hole (inlet **135***a*) is formed in the circular distal end plate **141***a*.

During the operation, the media are partially introduced into the media-separation-member receiving chamber. However, such media are separated from a treated-raw-material slurry and returned to the pulverization chamber again, by the media separation member **132** rotated within the media-separation-member receiving chamber, in the following manner.

Upon rotation of the media separation member **132**, the blade members **137** provided in a region of the transfer passage **135** on the side of the enlarged-diameter base portion **134***b* of the member body **134** performs a pumping action. Primarily based on this pumping action, the slurry and others in the transfer passage **135** are ejected outside the transfer passage **135** through the outlet **135***b*. In conjunction with the ejection, a suction force is generated at the inlet **135***a* so that a flow of the slurry and others from the inlet **135***a* is created, and a rotational movement is given to the flow. According to the rotational movement, the relatively large and heavy media are urged radially outwardly and separated from the slurry. In this process, a part of the target particles still having a relatively large particle size due to insufficient pulverization exhibit the same behavior as that of the media. On the other hand, the slurry containing particles sufficiently pulverized and reduced in size and weight are discharged to the outside of the media-agitation type pulverizer via the raw-material-slurry outlet passage **139**, the treated-raw-material-slurry collecting space **140** and the raw-material-slurry exit **131**.

The media separation member has the above structure, so that it becomes possible to stabilize a flow of media-containing raw material slurry inside and around the media separation member to form a non-turbulent flow field, thereby performing satisfactory media separation.

The media separation member illustrated in FIG. **6** and so forth has been described based on a structure configured to rotate the entire media separation member, i.e., a structure configured to rotate the central member together with the outer member. Alternatively, the media separation member may be configured such that only the central member is rotated, while fixing the outer member, as illustrated in FIG. **9**.

EXPLANATION OF CODES

10: media-agitation type pulverizer
12: pulverization container
14: pulverization chamber
16: raw-material-slurry supply port
18: frame
22: agitating member
24: rotary drive shaft
25: shaft seal
30: pulverizing media
32: media separation member
32*a*: hub
32*b*: closing plate
34: hollow rotary drive shaft
36: shaft seal
38: raw-material-slurry outlet
40: jacket
40*a*: coolant inlet
40*b*: coolant outlet
50: guide ring
52: annular inner-peripheral plate
54: annular outer-peripheral plate
56: annular lower plate
58: annular upper plate
60*a*: pipe
60*b*: pipe
70: thick-walled portion (media-separation-member receiving means)
72: through-hole (media-separation-member receiving chamber)
74: inner periphery of media-separation-member receiving means (thick-walled portion **70**)
76: protrusion
80: media-flow regulation means
82: cylindrical space
84: guide surface
90: flow straightening means
92: rotational-flow suppressing means

What is claimed is:

1. A media-agitation pulverizer comprising:

a pulverization container including an end plate closing up an upper end thereof and having an upright cylindrical pulverization chamber containing pulverizing media in the form of beads;

a raw-material-slurry supply port provided in the pulverization container;

an agitating member disposed in a bottom region of the pulverization chamber and having a rotary shaft substantially coaxial with a central axis of the pulverization chamber; and

a media separation member provided within the pulverization chamber and above the agitating member,

the media-agitation pulverizer being characterized in that it further comprises:

a guide ring installed to radially divide a lower region of the pulverization chamber into an inner section and an annular outer section, whereby a flow of a mixture of the raw material slurry and the pulverizing media is formed as a helicoidal flow comprising a combination of a primary flow flowing in a circumferential direction of the pulverization chamber and a secondary flow flowing through a circulation flow path which has an upward flow path and a downward flow path created, respectively, in the outer section and the inner section of the lower region of the pulverization chamber, with respect to the guide ring; and

rotational-flow suppressing means provided within the pulverization chamber for controlling the helicoidal flow to suppress the primary flow while strengthening the secondary flow, thereby stabilizing the helicoidal flow, the rotational-flow suppressing means being formed in a cruciform shape, and provided in the guide ring, and the guide ring with the rotational-flow suppressing means being provided above the agitating member.

2. The media-agitation pulverizer as defined in claim 1, wherein the rotational-flow suppressing means is formed by combining a plurality of plate members, and provided inside the guide ring.

3. The media-agitation pulverizer as defined in claim 1, wherein the media separation member is disposed within a cylindrical-shaped media-separation-member receiving chamber formed in media-separation-member receiving means provided at the end plate, and having a bottom formed as a downwardly-facing opening opened to the pulverization chamber, wherein the media-separation-member receiving chamber has an inner diameter greater than an outer diameter of the media separation member and less than an inner diameter of the pulverization chamber.

4. The media-agitation pulverizer as defined in claim 3, wherein the media-separation-member receiving chamber has a radius greater than a radius of the media separation member by 10 to 30 mm.

5. The media-agitation pulverizer as defined in claim 1, wherein the media separation member comprises: a circular top plate; a circular bottom plate disposed in axially spaced-apart relation to the top plate, and a plurality of blade members disposed between the top plate and the bottom plate at intervals in a circumferential direction thereof.

6. The media-agitation pulverizer as defined in claim 5, wherein the media separation member is formed in a multi-stage structure in which an intermediate plate is provided between the top plate and the bottom plate.

7. The media-agitation pulverizer as defined in claim 1, wherein the guide ring has a structure which is internally formed with an annular space, and supported by a plurality of pipes attached to the pulverization container, in such a manner as to allow liquid to be supplied and discharged to/from the annular space through the pipes.

8. The media-agitation pulverizer as defined in claim 7, wherein each of the pipes is disposed to extend downwardly from above the pulverization container and support the guide ring by a lower end thereof.

9. The media-agitation pulverizer as defined in claim 3, which further comprises media-flow regulation means disposed to surround the downwardly-facing opening of the end plate and adapted to restrict the pulverizing media in the pulverization chamber from flowing into the media-separation-member receiving chamber.

10. The media-agitation pulverizer as defined in claim 9, wherein the media-flow regulation means is composed of a downwardly-tapered truncated conical-shaped guide member having an internal space, the guide member being adapted to change an upward flow of the mixture of the raw material slurry and the pulverizing media created by an action of the agitating member, to a downward flow.

11. The media-agitation pulverizer as defined in claim 3, which further comprises at least one protrusion provided on an inner peripheral wall of media-separation-member receiving means, wherein the protrusion has a flow passage extending in a circumferential direction of the guide member to allow the pulverizing media to pass therethrough.

12. The media-agitation pulverizer as defined in claim 11, wherein the protrusion is formed in a triangular shape having a base on the inner peripheral wall of the media-separation-member receiving means.

13. The media-agitation pulverizer as defined in claim 11, wherein the flow passage is provided in a base portion of the triangular-shaped protrusion of the media-separation-member receiving means.

14. The media-agitation pulverizer as defined in claim 1, wherein the media separation member comprises: an approximately conical-shaped or truncated conical-shaped member body having a reduced-diameter distal end portion and an enlarged-diameter base portion; a transfer passage for the mixture, provided in the member body of the media separation member to extend from at least one inlet adjacent to the reduced-diameter distal end portion to an annular outlet in the enlarged-diameter base portion along a peripheral wall thereof, the inlet being adapted to act as a mixture suction hole for sucking the mixture to allow it to flow into the transfer passage; a plurality of blade members provided in the transfer passage at positions adjacent to the annular outlet and arranged side-by-side along the annular outlet to perform a media pumping action; and a raw-material-slurry outlet passage branched from the transfer passage at a position upstream of the blade members.

15. The media-agitation pulverizer as defined in claim 1, wherein the media separation member comprises: an approximately conical-shaped or truncated conical-shaped central member; and a generally hollow truncated conical-shaped outer member having an inner periphery located in spaced-apart relation to an outer periphery of the central member, and wherein the transfer passage is formed by the space between the outer periphery of the central member and the inner periphery of the outer member.

16. The media-agitation pulverizer as defined in claim 15, wherein the outer member of the media separation member has a distal end fixed to a distal end of the central member of the media separation member.

17. The media-agitation pulverizer as defined in claim 16, wherein the distal end of the outer member of the media separation member is formed as a circular distal end plate, and wherein the mixture suction hole is formed in the circular distal end plate.

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